HUMIC ACID

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Chemical Investigation of Peat

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Peat, the investigation of which is the subject of this treatise, is found near the village of Hertefeld within the district of Königshorst, 6 miles from Berlin. The ground in the vicinity is marshy and almost constantly covered with water. Only during dry years and only during the hottest months does the water sink to below 6 inches from the surface of the soil. This is when the peat is cut after the water has been diverted as much as is possible. The peat forms horizontal layers which differ in age and in quality. I differentiate three layers, the upper, middle, and lower one. The upper one is least suited for usage, the middle one is better and the bottom layer is best. It is thicker, its parts adhere more to one another and its specific weight is greater than that of the first two layers. The color is darker and one finds only a few particles of plants which have retained their outer shape whereas the other two and especially the first layer abound with leaves, small branches and roots of waterplants. This mixture of still-unaltered plant remnants, parts of which have already changed into peat, accounts for the lesser density of the first layer. I am now turning to the tests which I undertook in order to investigate the contents of this peat.

Investigation of the Peat in the First Layer

1st Test. I burned 6 ounces [the old German term "Unze" for ounce may not be the exact weight of the English ounce, i.e. it may range from 28.35 to 30 g.; the same holds true for the term "Zoll" for inch, which may range from 2.3–3 cm-*Transl*.] of peat in an iron vessel and obtained 4 1/2 "quents" [old German weight standard equaling approximately 1.67 g-*Transl*.] of a gray, going toward red form of ashes, without any taste whatever.

2nd Test. I poured some hydrochloric acid onto these ashes, which caused a lot of fizzing and thereby heated itself. A portion of the ashes was dissolved and colored the hydrochloric acid yellow. Eighteen "grans" [very minute weight standard formerly used in pharmacies and equaling approximately 65 mg-*Transl*.] remained undissolved. They consisted of a power in which, once it was dry, no trace of sand grains could be detected.

3rd Test. I exposed these 18 grans in a heavy pan to a melting furnace. They turned very white but showed no trace of any beginning of melting. I mixed them thereupon with a small amount of tartar salt and put them into a tuyère [he calls it a "windfurnace"-*Transl*.] where they melted completely and turned into a smooth mass on the surface and around the edges.

4th Test. To the extract with the hydrochloric acid from the second test I added vitriolic acid, whereupon a quantity of gypsum was formed which made the mixture somewhat thick.

5th Test. I put 5 ounces of peat into a glass retort and after I had put a receiver in place, I proceeded to distill it by allowing the fire to go out in stages. At first I received mucilage and after that 1 ounce of empyreumatic oil. The mucilage was yellow and had a burnt and alkaline odor; it weighed 2 ounces. The charcoal-like remainder in the retort weighed 2 1/2 ounces.

6th Test. I rinsed these remainders with distilled water, which turned somewhat yellow from it. After I had dried them, they weighed 2 ounces and 3 quents so that only 1 quent had been dissolved. I burnt it in an open vessel and obtained 1/2 ounce 50 grans of gray ashes, going toward red. I slowly evaporated this solution until it was dry and obtained a brown matter which strongly attracted the humidity in the air. It had no alkaline taste but rather approached the taste of carrot juice. An acid which I added did not result in the least amount of fizzing.

7th Test. I put 1 ounce of peat into an earthenware retort, and attached a glass tube to it which emptied into a vessel with water. Above the opening [of the retort?-*Transl*.] I attached a glass bottle filled with water, the mouth of which was also submerged in the water. I then began heating it in stages until the retort glowed red. I obtained 4 quarts [?-*Transl*.] of air. The first was transparent; the following frequently mixed with white steam which had a milky look to it which, however, dissipated after some time when the steam got denser. I shook up the first amount of air with water. It, however, was not absorbed but caught fire from the flame of a candle. The same happened with the rest of the air.

8th Test. I boiled four ounces of peat with so much water as was necessary to dissolve the soluble parts. Then I dried the boiled peat. It weighed 3 ounces, 5 quents so that 3 quents had been dissolved. The solution was brown and was evaporated until dry. The remainder was also brown, tasted very bitter and weighed ~/z quent.

9th Test. I poured 8 ounces of the best ethanol [spirit of wine-*Transl*.] onto 1 ounce of peat. After letting it dissolve for one day, the spirit of wine was colored yellow. Some very light white flakes had settled on top of the peat which had a crystal look to them, but which disappeared after a few days. I filtered the spirit of wine and thereupon weighed the leftover peat whose weight still amounted to 1 ounce. I mixed the spirit of wine with water but it did not turn cloudy.

l0th Test. I poured a solution of caustic tartrate over 2 ounces of peat which turned a very dark brown from this [due to extracted humic acid-*RJL*]. I put the liquid through a sieve and poured distilled water over the remainder for as long as it still retained any color. I dried the remainder in the air. It became very hard from this and could only be ground into a powder with the help of a marble pestle. The weight from this amounted to 1 ounce, 2 quents, 50 grans. These remainders were much darker brown than the peat and almost black; it burned well and left behind some very white ashes. In order to see whether the caustic alkali could still be dissolved from the remainder, I boiled 4 scruples [smallest parts of a weight, formerly used in pharmacies, approximately 1.25 g-*Transl*.] together with a sufficient amount of the caustic alkaline solution: but the remainder had lost

nothing of its weight after drying. Therefore, the caustic alkaline had already dissolved all the parts during the first attempt to dissolve it.

11th Test. I saturated the extract of the peat obtained in the former test with vitriolic acid [fuming sulfuric acid?-*Transl*.]. The mixture turned cloudy and a dark brown; a nearly-black sediment settled at the bottom which, after it was recausticized and dried, weighed 2 l/2 quents and was as combustible as the peat.

12th Test. I dissolved 1 ounce of peat in turpentine oil which turned yellow. At the bottom of the vessel settled a jelly-like transparent matter which resembled a thick oil, but which disappeared again after a few days. The peat had not changed its color and the turpentine oil did not seem to have dissolved any significant part of it.

13th Test. I poured 6 ounces of nitric acid onto 1 ounce of crumbled-up peat, which caused a violent foaming and developed a great amount of saltpeter air. The saltpeter spirit which had absorbed the soluble parts was reddish brown; after it was dried, it left behind a brown mass which strongly attracted the humidity in the air. This mass, when put into a covered vessel, ignited. The ashes from this weighed 2 scruples. The part of the peat which had not been dissolved by the nitric acid weighed 50 grans after drying. It contained a lot of sand, and, apparently, more than half of its weight.

14th Test. I poured 8 ounces of hydrochloric acid onto 2 ounces of powdered peat and dissolved this for 12 hours. There was no foaming, and the solution turned brown. I separated it from the peat which, after having been recausticized, weighed 1 ounce, 3 quents. The extract was evaporated; the residue from this weighed 4 i/2 scruples.

Examination of the Peat from the Second Layer

15th Test. I burned 6 ounces of the peat to ashes: it was without taste, of a gray color, going toward red, and weighed 1/2 ounce, 55 grans.

16th Test. I poured hydrochloric acid onto these ashes, which caused heavy foaming and heating. It was dissolved almost entirely down to 35 grans by the hydrochloric acid. The part which was not affected by the acid was very dark gray. I did not observe any sand grains in it.

17th Test. I poured vitriolic acid onto the solution containing the hydrochloric acid from the previous test. The mixture became cloudy and a lot of selenite settled to the bottom.

18th Test. I distilled 6 ounces of peat from a retort with increasing fire and obtained a yellow mucilage with a burnt odor, which weighed 2 1/2 ounces and, after that, some fugitive alkali which had crystallized in the neck of the recipient and 1 ounce of black thick oil. Since the retort broke, I could not determine the weight of the residue.

19th Test. I put 1 ounce of peat into an earthenware retort, at the mouth of which was attached a glass tube submerged in water as in the 7th test. I heated it in stages until the retort glowed and obtained 6 quarts of air. The first air was already combustible, and the more I increased the fire the more frequently white vapors formed which, however, disappeared again after some time.

20th Test. I boiled 4 ounces of peat for several hours with a sufficient quantity of water in order to extract the soluble parts from this. It lost 1/2 ounce in weight. The solution was dark brown and after evaporating left behind an equally colored, tasteless mass, weighing 3 scruples [more humic acid-*RJL*]. The peat had not changed its color during boiling.

21st Test. I dissolved 1 ounce of peat in a glass with 6 ounces of the best wine spirit, which was slightly colored by it but which retained its transparency when water was added. There were little white flakes suspended in the wine spirit which had a crystalline look to them, which they lost, however, after a few days. The peat lying on the bottom retained its color and lost little of its weight.

22nd Test. I poured 1 1/2 ounces of a caustic tartrate solution onto 2 ounces of powdered peat and heated it until boiling. The solution turned dark brown [more humic acid-RJL]. I diluted the undissolved peat with boiling water and dried it, which rendered it very hard. It weighed 1 ounce, 3 quents which burned just like normal peat and left behind some very white ashes.

23rd Test. I saturated the extract with the help of the alkaline solution from the previous test with vitriolic acid, which rendered the extract cloudy and caused a dark brown sediment [humic acid precipitate-*RJL*]. This sediment, after recausticizing and drying, weighed 1/2 ounce, 2 scruples; it ignited and burned just like normal peat.

24th Test. I dissolved another part of peat in the caustic alkaline solution and distilled this solution from a glass retort by increasing the fire until the retort glowed red. The mucilage was followed by several drops of a heavy, very thick, oil with a burnt smell. A larger part of this remained in the neck of the retort. The watery liquid obtained at first had a pungent taste, smelled of a burning, fugitive alkaline, and foamed with acids.

25th Test. I dissolved 1 ounce of peat with turpentine oil, which turned yellow. A transparent, jelly-like mass, resembling thick oil, settled to the bottom of the glass, but which disappeared, however, after a few days. The peat had not changed its color and lost nothing significant of its weight.

26th Test. I poured 8 ounces of nitric acid onto 1 ounce of powdered peat, causing it to foam a lot and to heat, whereby a lot of saltpeter air was developed. The solution turned dark brown and the peat lying at the bottom (on which the nitric acid no longer had an effect) took on a jelly-like consistency. I spilled it when I wanted to take it from the filtering cloth so that I retained only 36 grans.

27th Test. I evaporated this extract with the help of the nitric acid until it was dry. The residue was brown and strongly attracted the humidity from the air. I put it into a covered pan from which I removed the lid when it was red-glowing. The mass ignited immediately and left behind 1 quent of ashes.

28th Test. I dissolved 2 ounces of peat with 10 ounces of hydrochloric acid, which turned very dark brown from it. The peat treated in this fashion did not change its color. It also burned and turned to ashes just as normal peat. Its weight was 1 ounce, 2 quents.

29th Test. I evaporated the extract with hydrochloric acid from the previous test until it was dry, then heated it until glowing in a pan because it strongly attracted the humidity from the air. It weighed 5 scruples.

Investigation of the Third Layer of Peat

30th Test. I burned 6 ounces of peat to ashes; it was of a gray color, going toward red, and weighed 5 quents, 25 grans. On this I poured hydrochloric acid, which caused heavy foaming and heated up a lot. Parts of the ashes were dissolved. The undissolved part was black and weighed 50 grans. I did not notice any sand grains in it. It turned white in the fire without melting. I mixed it with the tartrate and exposed it again to a hot fire whereby it turned into a black, grasslike, nearly opaque mass.

31st Test. I mixed the extract from the previous test with vitriolic acid, which caused the solution to turn cloudy and a lot of selenite settled to the bottom.

32nd Test. I distilled 6 ounces of peat from a glass retort by heating it in stages until it was glowing red. At first I obtained mucilage, which was followed by 6 quents of a burnt oil. In the neck of the receiving flask I found some crystallized fugitive alkaline. The mucilage weighing 1 1/2 ounces contained some of that [in-*Transl*.] dissolved [form-*Transl*.] because it tasted alkaline and empyreumatic. It foamed with acids. The charred residue weighed 2 ounces, 5 quents. I rinsed it, weighed it again, and found 2 1/2 ounces, 1 scruple. I burned it and obtained 5 quents, 35 grans of ashes. I evaporated the resultant solution and obtained a brown, syrup-like mass which tasted alkaline and foamed with acids.

33rd Test. I placed 1 ounce of peat into an earthenware retort and after I had attached an air apparatus as earlier, I heated it in stages until the vessel was glowing red. I obtained 5 quarts of air. The last portion was filled with white vapors, which rendered it opaque. These vapors soon condensed and returned transparency to the air. It was not absorbed by water. It ignited when a candle was held to it.

34th Test. I boiled 4 ounces of peat with sufficient water and dried it again. It had lost ~/: ounce in weight; the water had taken on a dark brown color. I evaporated it and obtained a dry powder, 1 scruple in weight. It was nearly black and tasted very bitter.

35th Test. I dissolved 1 ounce of powdered peat in 8 ounces of wine spirit, which turned yellow from it. Several white light flakes were suspended in the solution. After a few days they settled to the bottom and lost their crystalline appearance. After I filtered the wine spirit I added water, which did not cloud it. The peat did not change its color and did not lose significant weight.

36th Test. I boiled 2 ounces of peat with 1/2 pound of a caustic tartrate. I recausticized the undissolved peat with water; it turned very hard after drying and weighed 1 1/2 ounces and 1/2 quent. It burned like raw peat and left behind some very white ashes. I saturated the caustic solution which had turned dark brown [more humic acid-*RJL*] with vitriolic acid, which created a nearly black sediment [precipitated humic acid-*RJL*]weighing 2 1/2 quents. It burned and turned to ashes just like normal peat.

37th Test. I dissolved 1 ounce of powdered peat with several ounces of turpentine oil, which turned yellow from it. There were several jelly-like colorless transparent particles at the bottom, which resembled thick oil. After a few days they disappeared. The peat had retained its color, and the oil appeared to have dissolved very little of it.

38th Test. I poured 8 ounces of nitric acid onto 1 ounce of peat, which resulted in heavy foaming and heating whereby much saltpeter air was developed. The acid was very dark brown and left behind a mass after evaporation which strongly attracted the humidity from the air. I heated this mass to glowing in a covered pan. When I opened the lid, it ignited and left behind white ashes weighing 1 quent. I recausticized the undissolved portion of the peat; it had a jelly-like consistency so that I could separate it only incompletely from the filtering cloth, and much was spilled during that process. That which I obtained was very hard after drying, and weighed 36 grans. It burned, incidentally, just like raw peat.

39th Test. I dissolved 2 ounces of powdered peat in 8 ounces of hydrochloric acid, which turned brown from it. I evaporated it and obtained a residue which strongly attracted the humidity from the air. I heated this to glowing in a covered pan. When I opened it, it ignited. The weight from it was 4 scruples. The part of the peat which had not been dissolved by the hydrochloric acid still weighed 1 1/2 ounces. It still had its former color and burned just like normal peat.

The tests which I have mentioned in this treatise prove that the peat from all three layers consists of the same basic substance and only differs in terms of the quantity of each of its composite parts.